1.0 Introduction

Queen Creek begins in the Tonto National Forest below Fortuna Peek as a high gradient, intermittent, arid mountain stream. Queen Creek's flows begin at its headwaters located at the foot of Fortuna Peak in Pinal County, Arizona within the larger Middle Gila Watershed. Queen Creek descends southwesterly towards and through the town of Superior and continues into the Roosevelt Irrigation Canal. The upper watershed is dominated by bedrock outcrops and shallow soils. A second high elevation tributary originates on the easterly side of a prominent ridge known as Apache Leap and joins Queen Creek in the area known as Oak Flat. From here Queen Creek flows steeply approximately 2.5 miles along US Highway 60 toward the Town of Superior. From Superior to the Whitlow flood control dam, the stream takes on the characteristics of a low gradient, desert foothill stream dominated by thick piedmont sediments and infrequent undulating bedrock.

Climate in the Queen Creek watershed varies substantially from the mountains, being much cooler and wetter, to the lower deserts, being hotter and much drier. The region has two wet seasons: one during the summer monsoon season with increased and intense precipitation characterized by spotty and short duration convective thunderstorms, and the second in the winter as longer duration events associated with passing low-pressure cold fronts characterized by evenly distributed precipitation. Snow does occur in the higher elevations but typically any accumulated snow melts off within a few days. The portion of the Queen Creek study reach begins at the headwaters and flows approximately 13 miles to Queens Station, below the confluence of Potts Canyon (**Figure 1-1**).

The Queen Creek watershed has a long history of mining with numerous abandoned/inactive mines, historic smelter operations, and mineral prospects. Queen Creek has been included on Arizona's 303(d) List as impaired for exceedances of the dissolved copper surface water quality standards since 2002. Recent water quality results have also indicated that total lead is an additional pollutant of concern which will require completion of a Total Maximum Daily Load (TMDL).

As part of the TMDL planning process, the Arizona Department of Environmental Quality (ADEQ) implemented various monitoring programs and modeling studies to identify and quantify the diverse sources of copper and lead in the watershed causing these impairments. In February 2010, ADEQ staff completed the calibration and validation of the Hydrological Simulation FORTRAN (HSPF 12) for dissolved copper in the Queen Creek watershed (Arizona DEQ, 2010). In support to this initial modeling effort, ADEQ implemented a comprehensive and extensive sampling and analysis plan, using automated instrumentation, geared towards developing the needed parameters to populate the HSPF model. ADEQ collected numerous water quality grab samples across the watershed to characterize water quality from various sources, landuse types and bedrock lithologies. The HSPF model was calibrated for streamflow at numerous stations within the watershed. The water quality monitoring data was used to develop the HSPF copper loading factors along with the calibration of the water quality component of the model.

This initial HSPF application exhibited an acceptable hydraulic and pollutant calibration for dissolved copper and indicated that natural background in bedrock and soils, semi-active and abandoned mines, and historic smelter fallout, constitute the main source of copper and lead in the Queen Creek watershed. The modeling study also concluded that the degree to which these disturbances have affected water quality is generally unknown, and may not be able to be discerned from the natural geologic sources with the current set of data. In order to address these issues and to further understand and discern between natural and anthropogenic sources of dissolved copper and total lead in the Queen Creek watershed, ADEQ implemented a supplemental and extensive monitoring program and collected additional copper and lead water quality and lithologic data.

The main objective of this study is to incorporate the additional data in the existing model representation and refine the existing ADEQ dissolved copper model calibrations in the Queen Creek watershed. The goal is to fill the spatial water quality data gaps within the watershed to fine-tune the HSPF model spatial representation of dissolved copper, implement various modeling scenarios, and attempt to discern/separate the natural and anthropogenic sources of copper causing the impairment in the Queen Creek watershed. This new additional data; along with the existing data, will also serve for the implementation of the total lead model and the representation of the source-loadings in the Queen Creek watershed.

Subsequent to this introduction, the remainder of this section presents the applicable water quality standards and the point source in the watershed, discusses the identification of the mining areas, and presents the overall landuse and geologic distribution in the Queen Creek watershed.

Section 2 presents a detailed summary of the types and sources of data developed by ADEQ in support of the Queen Creek TMDL modeling.

Section 3 details the implementation of the HSPF model including the hydrologic and pollutant calibrations. Section 3 also presents the various modeling scenarios implemented for dissolved copper and total lead.

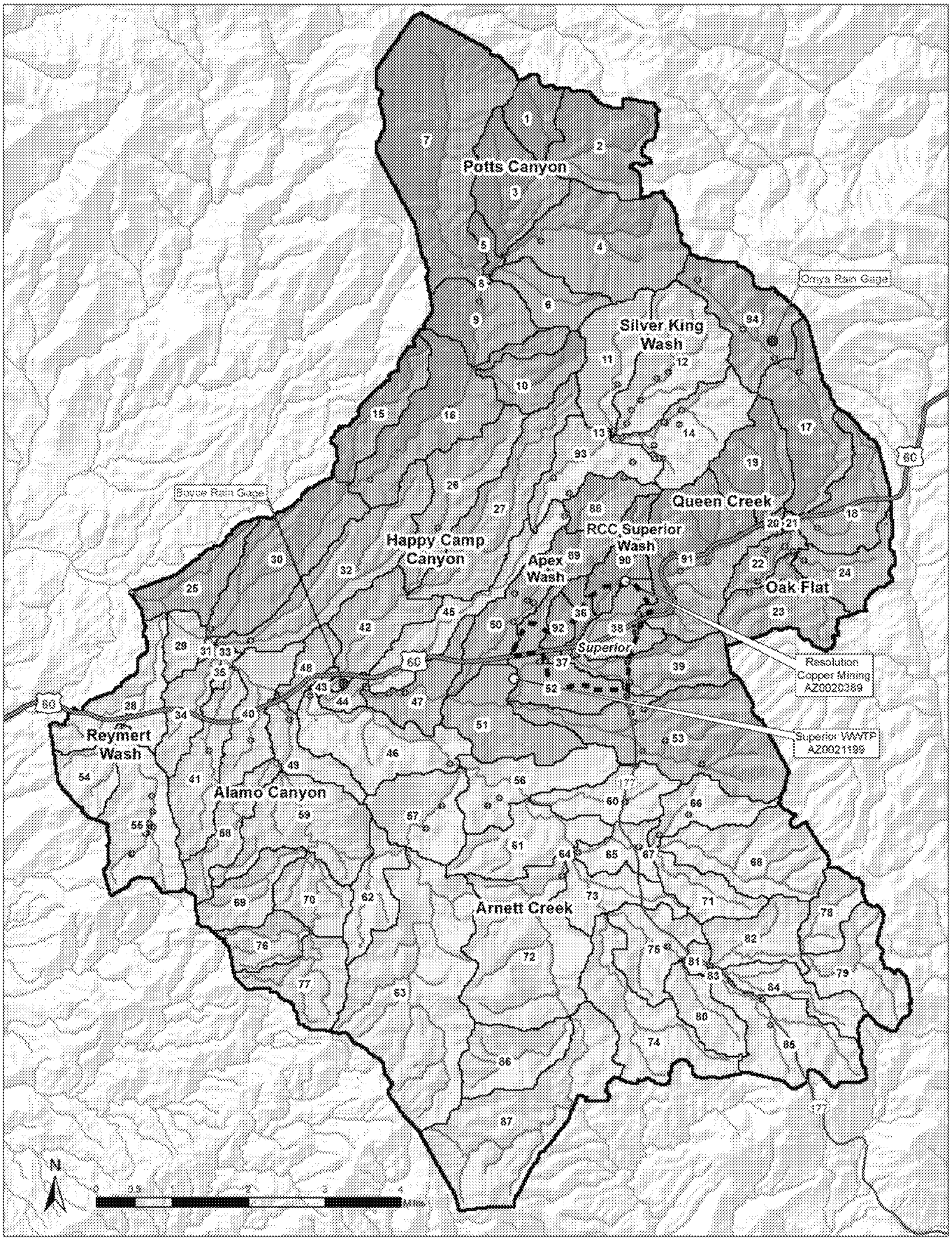

Figure 1-1: Queen Creek Watershed

1.1 Applicable Water Quality Standards

Designated uses of Queen Creek include Aquatic and Wildlife Warm water (A&Ww) and Full Body Contact (FBC). Historically, the flow regime in the upper stream reach has been classified as ephemeral. Ephemeral streams flow only in direct response to precipitation. Recent ADEQ biological and hydrological investigations have led to an intermittent flow regime reclassification (Arizona DEQ, 2011, Fact Sheet for Queen Creek Total Maximum Daily Load). Intermittent streams flow continuously only at certain times of the year, as when it receives water from a spring or from another surface source, such as melting snow. This shift changed the designated use of the stream reach from Aquatic and Wildlife ephemeral to A&Ww. The reclassification of the designated uses lowers the dissolved copper standards designed to protect the aquatic life and wildlife that use these streams as habitat and sources of drinking water. The water quality standards for dissolved copper are hardness-based with the more stringent standard designed to protecting A&Ww from chronic exposure. The most stringent surface water quality standard for total lead is based upon the FBC standard of 15 micrograms per liter (µg/L) (**Table 1-1**).

Table 1-1: Applicable Water Quality Standards in Queen Creek

Pollutant	A&Ww Acute (µg/L)	A&Ww Chronic (µg/L)	FBC (µg/L)
Dissolved Copper	$(e^{(0.9422[\ln(hardness]-1.7)})*0.96$	$(e^{(0.8545[\ln(hardness]-1.702)})*0.96$	No Numerical Standard
Total Lead	No Numerical Standard	No Numerical Standard	15

1.2 Point Sources

The Superior Waste Water Treatment Plant (SWWTP) (AZ0021199) is the one of two known point-sources in the watershed. The Resolution Copper Company – West Plant Facilities, adjacent to the Town of Superior, have also been issued an AZPDES permit. A draft renewal permit dated 3/19/2008 (AZ0020389) was reviewed for this project. According to the file and ADEQ Permits Staff, the facility is reportedly designed to contain all runoff up to and including the 100-year, 24-hour event. Thus, the RCC discharge point 001 is non-discharging in the range of storm magnitudes being simulated for the estimation of the copper and lead loads (**Chapter 3**). RCC has proposed, and then withdrawn, an AZPDES permit application to discharge treated mine dewatering water to Queen Creek adjacent to their existing 001 outfall. At this point there is no information that a future request to discharge this water is pending. Currently, water is transported approximately 30 miles westerly of Superior via pipeline to an irrigation district. The water transfer currently occurs during the growing season only, reportedly forcing RCC to halt mine dewatering during the winter months.

1.3 Abandoned, Inactive, and Semi-active Mines

The Queen Creek watershed has long history of mining, with numerous abandoned/inactive mines and mineral prospects. ADEQ collected water quality samples around three semi-active metals mines; Resolution Copper Co., Silver King Mine, and the Reymert Mine. Fourteen individual small inactive/abandoned mines were identified in the mines GIS cover, and then confirmed by inspecting the aerial photography for evidence of site disturbance. Those sites identified as having copper, lead, or other metals in the database and exhibiting some disturbance, were provided a land use category in the model. The footprint size, shape and location are based on the actual land disturbance as can be observed from the aerial images. In 2010 ADEQ collected additional copper and lead samples at several abandoned mines in the watershed focusing on waste piles in abandoned mines, mine shafts, mine openings, and excavation walls.

1.4 Landuse and Geologic Data

ADEQ developed the landuse distribution using the geology and landuse GIS cover. The landuse data is based primarily on the geologic units exposed at the surface as well as anthropogenic uses. ADEQ acquired geologic information from the Arizona Geologic Survey and manually edited by visual reference to features observed on aerial photographs. Landuse edits included overlaying several types of human altered lands including: urban/industrial areas, mines/mills, and other disturbed lands. The resulting landuse distribution in the queen Creek watershed is presented in **Table 1-2**.

Table 1-2: Landuse and Geologic Distribution in the Queen Creek Watershed

Landuse Type	Description	Number of Areas	Acres	Percent of watershed
Pinal Schist	schist, phyllite, amphibolite, calc-silicate, and gneiss	51	13,520	21.9%
Apache Group	quartzite, diabase, paleozoic's and naco formation	43	13,148	21.3%
Granite/ Crystalline	granite, diorite, granodiorite, porphyrys	26	5,178	8.4%
Volcanics	basalt, lavas, intrusions and other volcanics	43	7,078	11.5%
Alluvium	surfical, river, fan and terrace deposits, talus	56	4,558	7.4%
Metal Mining and Milling	known mines with copper and/or lead ores	18	772	1.3%
Sedimentary	sandstone, siltstones, conglomerates	39	6,982	11.3%
Tuff	Apache Leap and Picketpost tuffs	46	9,467	15.4%
Urban Industrial	Town of Superior and other developed areas	12	415	0.7%
Impervious urban Industrial	Town of Superior and other developed areas	12	506	0.8%
Total		**346**	**61,624**	**100.0%**

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